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YAKIMA RIVER RADIO-TELEMETRY STUDY RAINBOW TROUT

CHANDLER CANAL FISH COLLECTION FACILITY, YAKIMA

Annual Report 1993

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RAINBOW TROUT

ANNUAL REPORT 1993

Prepared by:

Eric Hockersmith
John Vella
and
Lowell Stuehrenberg

Coastal Zone and Estuarine Studies Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Seattle, WA

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P. O. Box 3621
Portland, OR 97208-3621

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CONTENTS

INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) populations in the upper Yakima River Basin have increased due to reduced competition from declining populations of steelhead, chinook salmon, and coho salmon (Campton and Johnston 1985). Changing population abundances have increased the potential for interactions between rainbow trout and steelhead.

The Washington Department of Wildlife (WDW) began investigating resident and anadromous fish interactions within the Yakima River Basin in 1989. Interactions between steelhead and rainbow trout in the upper Yakima River Basin (above Roza Dam) were of special concern because spawning interactions between steelhead and rainbow trout could adversely affect the rainbow trout population or affect the success of supplementation programs (Pearsons et al. 1993).

Steelhead spawning distribution and timing in the Yakima River Basin were investigated as part of National Marine Fisheries Service (NMFS) radio-telemetry studies, conducted from 1989 to 1993 (Hockersmith et al. 1994). Pearsons et al. (1993) recommended conducting a similar study to identify the spawning distribution and timing of rainbow trout in the upper Yakima River Basin, in order to compare spawning interactions between rainbow trout and steelhead.

In 1993, NMFS, in cooperation with WDW, proposed a l-year radio-telemetry study to determine the spawning distribution, timing, and behavior of rainbow trout in the upper Yakima River Basin.

Specific objectives were to:

1) Determine the spatial and temporal spawning distributions of rainbow trout in the upper Yakima River Basin.
2) Describe postspawning behavior of rainbow trout in the upper Yakima River Basin.
3) Determine the magnitude and causes of mortalities to rainbow trout that were radio-tagged.

MATERIALS AND METHODS

Study Area

The Yakima River flows 349 km southeast from its headwaters in the Cascade Range (elevation 746 m) to its confluence with the Columbia River (elevation 91 m) near Richland, Washington, draining an area of 15,941 km^2. This study was limited to the upper Yakima River Basin above Roza Dam (river kilometer (RKm) 205.9), with emphasis on the Yakima River canyon section of the mainstem (Fig. 1). Major tributaries in the upper Yakima River Basin include Umptanum Creek, Wilson Creek, Cherry Creek, Manashtash Creek, Taneum Creek, Swauk Creek, the Teanaway River and the Cle Elum River. For study purposes, the mainstem Yakima River was subdivided into sections similar to those described by McMichael et al. (1992) (Table 1). Johnson (1964), Fast et al. (1991), and McMichael et al.. (1992) provide additional descriptions of the study area.

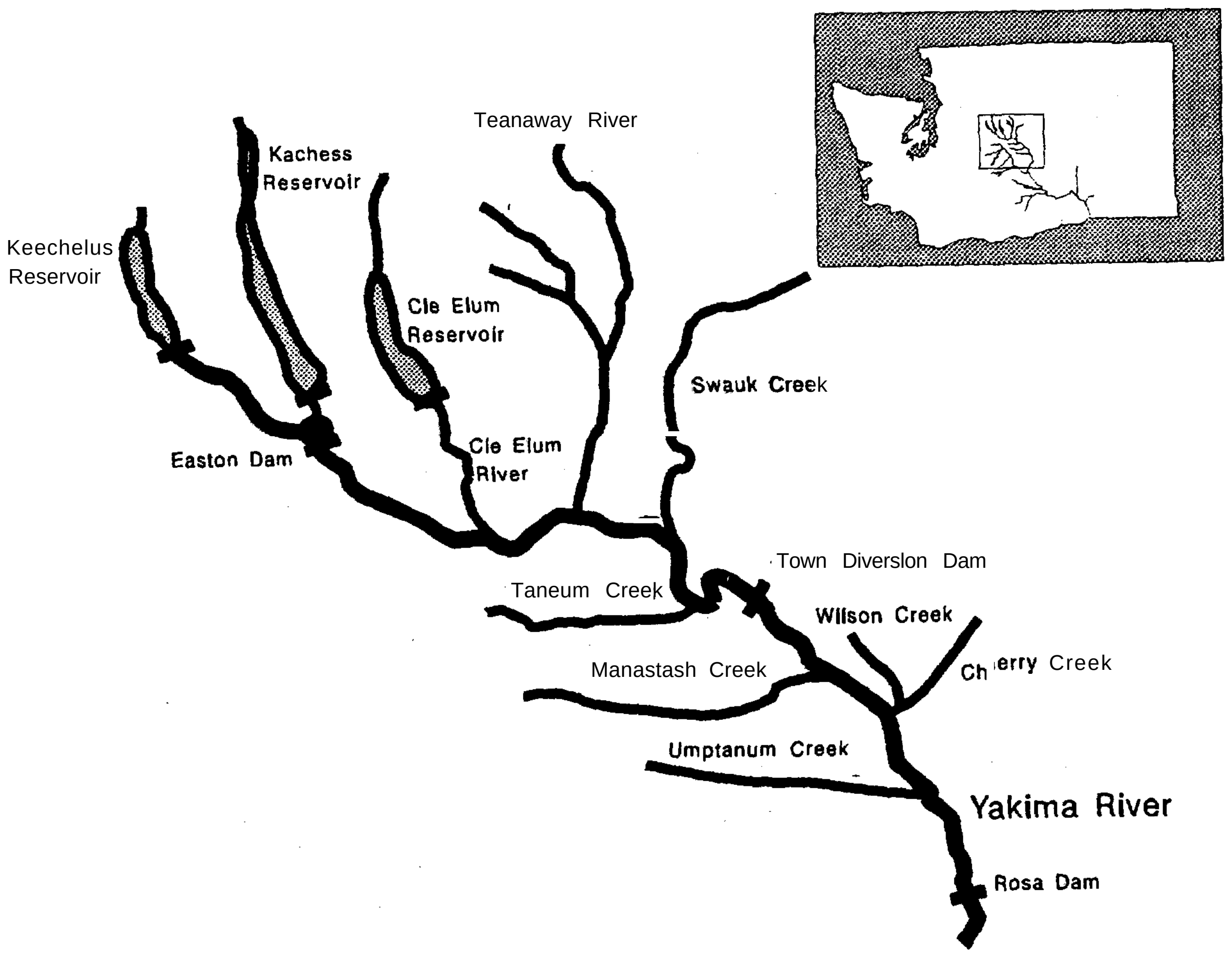

Figure 1. Location of rainbow trout radio-telemetry study, 1993.

Table 1. Section descriptions and locations in the mainstem upper Yakima River.

Section	Description	RKm
Lower Canyon	Roza Dam to Umptanum Creek	206-225
Upper Canyon	Umptanum Creek to Ringer Rd Access	225-239
Ellensburg	Ringer Rd Access to Town Diversion Dam	239-258
Thorp	Town Diversion Dam to Teanaway River	258-283
Cle Elum	Teanaway River to Cle Elum River	283-299

Radio Tags

Radio tags were purchased from Advanced Telemetry Systems, Inc[1]. Each tag was powered by a 3.7-V lithium battery and had a life span of at least 5 months.

The transmitter and battery were sealed in a 5.5-cm-length by 1.0-cm-diameter epoxy capsule and weighed 9.0 g in air (3.6 g in water). Each transmitter had a 21.0-cm flexible external whipantenna attached to one end. The tags transmitted on 1 of 9 frequencies spaced 10 kHz apart (30.17 MHz to 30.25 MHz). The bandwidth of each pulse provided individual identification codes for each tag.

Surveillance Equipment and Procedures

Two types of telemetry receivers were used to locate tagged fish during the study. Both types operated on 12-V DC and consisted of a radio receiver, data processor, internal clock, and data logger. Data loggers recorded month, day, hour, minute, tag code, and receiving antenna number. The first type of receiver (Model SRX-400) was purchased from Lotek Engineering Inc. These units were used in vehicles, boats, and as fixed-site monitors. The second type of receiver was developed and manufactured by NMFS electronics shop personnel and had a higher scanning rate than Lotek receivers (1.5 vs 13.5 seconds per cycle). These units were used in vehicles, boats, airplanes, and as fixed-site monitors.

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[1] Reference to trade names does not imply indorsement by National Marine Fisheries Service.

Self-contained, fixed-site monitors were installed to record the presence and activities of radio-tagged fish in specific areas. A fixed-site monitor consisted of a receiver system, power supply, antenna switching box, and either single or paired antennae. Surveillance data from fixed sites were downloaded and processed at least once per week.

Tuned-loop antennae'were used to monitor fish in a general area or to monitor fish passage by the combination of two antennae (one upstream and one downstream). Locations and antennae configurations for fixed-site monitors were determined from consultation with WDW and are indicated in Table 2.

Aerial surveillance of the upper Yakima River and its major tributaries was conducted once per week, weather permitting. Locations of radio-tagged individuals were determined from latitudinal and longitudinal coordinates provided by a global positioning system.

Mobile telemetry receivers were used twice per week from tagging through the spawning period and once per week after spawning to collect information on fish locations.

Turbid water conditions and the remoteness of some locations during spawning limited direct observations of rainbow trout spawning. Spawning locations and timing were designated when a fish moved out of its prespawning home range and subsequently returned or established a new home range.

Table 2. Locations and antennae configuration for fixed-site telemetry monitors.

Monitor number	Monitor location	Monitor type	River	River km	Antennae number	Antennae location
71	Prosser Dam	Lotek	Yakima	75.4	1	Across
12	Roza Dam	NMFS	Yakima	204.6	1	Across
15	Ringer Road	NMFS	Yakima	238.9	1	Across
51	Wilson Creek	NMFS	Wilson	0.8	1	Across
52	Cherry Creek	NMFS	Cherry	0.2	1	Across
53	Manatash Creek	Lotek	Manashtash	0.4	1	Across
54	Teanaway River	NMFS	Teanaway	0.4	1	Across
13	Town Diversion Dam	Lotek	Yakima	258.4	1	Downstream
13	Town Diversion Dam	Lotek	Yakima	258.4	2	Upstream
14	Easton Dam	Lotek	Yakima	324.0	1	Downstream

Collection and Tagging

Rainbow trout were collected using DC electrofishing equipment operated from a drift boat by WDW personnel on 5 and 8 March. Fish were captured in the early morning hours (0200-0600 hours) on the day of tagging and held in a 0.9-m-high by 1.2-m-long by 1.2-m-wide live-box near tagging locations. Tagging was performed at five locations, two in the upper canyon section and three in the lower canyon section. Twenty-five rainbow trout were tagged from each of the upper and lower canyon sections. Two additional rainbow trout, one each on 7 and 13 April, were surgically tagged with transmitters recovered from mortalities.

Fish were anesthetized in a 19-liter bucket containing a 100 mg/L solution of tricaine methanesulfonate (MS-222). After examination for tags, injuries, and stage of sexual maturity, fish were measured and weighed. Only fish weighing more than 300 g were radio-tagged to limit the weight of the transmitter to less than 3% of the fishes' weight, as recommended by Winter et al. (1978).

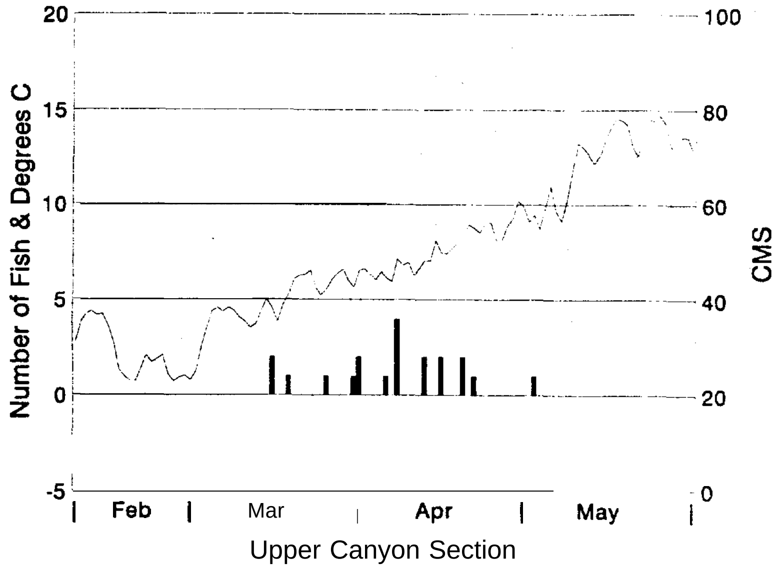
Tagging techniques were similar to those described by Hart and Summerfelt (1975), Mellas and Haynes (1985), Reinert and Cundall (1982), and Ross (1982). Surgical tools and transmitters were sanitized in a solution of benzalkonium chloride. After placing the fish into a tagging cradle (ventral side up), a radio transmitter was surgically implanted into the body cavity by making a 3-cm incision in the mid-ventral bodywall. The incision was closed with 3 to 5 individual stitches of prepared, absorbable, braided polyglycolic acid suture and a 19-mm CE-4 quarter-round cutting needle. The transmitter's antenna was threaded through the body cavity and out the base of the caudal peduncle. Baciguent, an antibiotic ointment, and Betadine were applied to the suture and antennae exit areas to prevent infection. Average surgery time was 10 minutes.

Rainbow trout were also externally marked with individually numbered Hallprint T-bar anchor tags for identification in the sport fishery. Fish were allowed to recover in fresh water until they regained equilibrium, at which time they were placed in a live-box in the river. Fish were released after approximately 30 minutes. Tagging data for individual rainbow trout are indicated in Appendix Table A.

RESULTS

Spawning Behavior

Fifty-two rainbow trout were surgically implanted with radio-tags, half each from the lower and upper canyon sections of the upper Yakima River. Rainbow trout initiated spawning migrations in response to increased flow and water temperature (Fig. 2). Migration data for individual radio-tagged rainbow trout are indicated in Appendix Table B. Most spawning fish migrated upstream within the mainstem Yakima River except for four fish that moved downstream to spawn in Umptanum Creek. Rainbow trout migrated from 0.3 km to 87.2 km, but the majority (71%) migrated less than 15 km to spawn (Fig. 3). Spawning



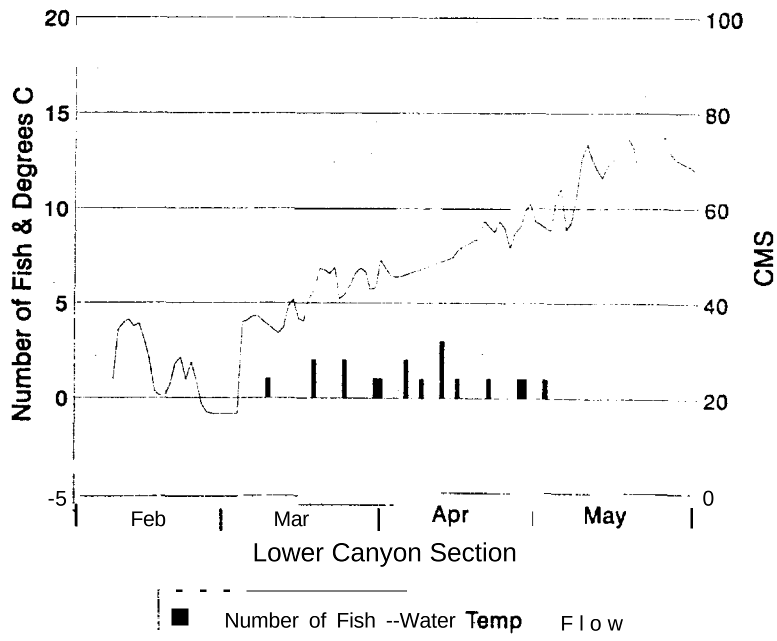


Figure 2. Radio-tagged rainbow trout initiation of spawning migrations and Yakima River canyon water temperature and flow.

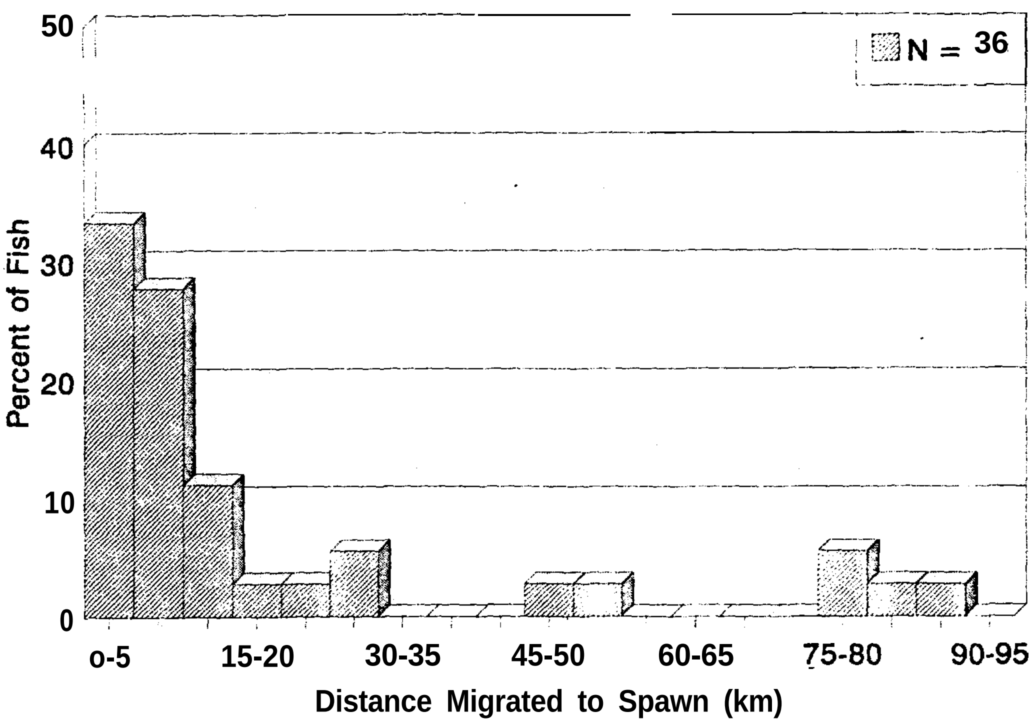


Figure 3. Spawning migration distance of radio-tagged rainbow trout.

migrations ranged from 1 to 30 days in duration; however, the majority (91%) were completed in less than 16 days (Fig. 4).

Of the 52 radio-tagged rainbow trout, 75% (39 fish) spawned during 1993. Radio-tagged rainbow trout spawned from RKm 212.1 to RKm 298.8 in the upper mainstem Yakima River and in three tributaries to the mainstem (Umptanum Creek, Cherry Creek, and the Teanaway River). In 1993, 82% (32) of the fish spawned in the mainstem Yakima River (Fig. 5). Spawning locations and timing of individual radio-tagged rainbow trout are indicated in Appendix Table B. The majority (71.8%) of the radio-tagged rainbow trout spawned in the mainstem Yakima River between Roza and Town Diversion Dams. Radio-tagged rainbow trout that spawned above Town Diversion Dam were only from the lower canyon section population.

Rainbow trout spawned between 24 March and 11 May during 1993 and remained on the spawning grounds from 1 to 34 days (mean 10.8 days). Water temperature during spawning ranged from 7.2°C to 10.6°C. Peak spawning occurred earlier in lower elevations (Umptanum Creek and the canyon sections of the mainstem Yakima River) than in higher elevations (Teanaway River and sections of the mainstem above the Yakima River canyon) (Fig. 6).

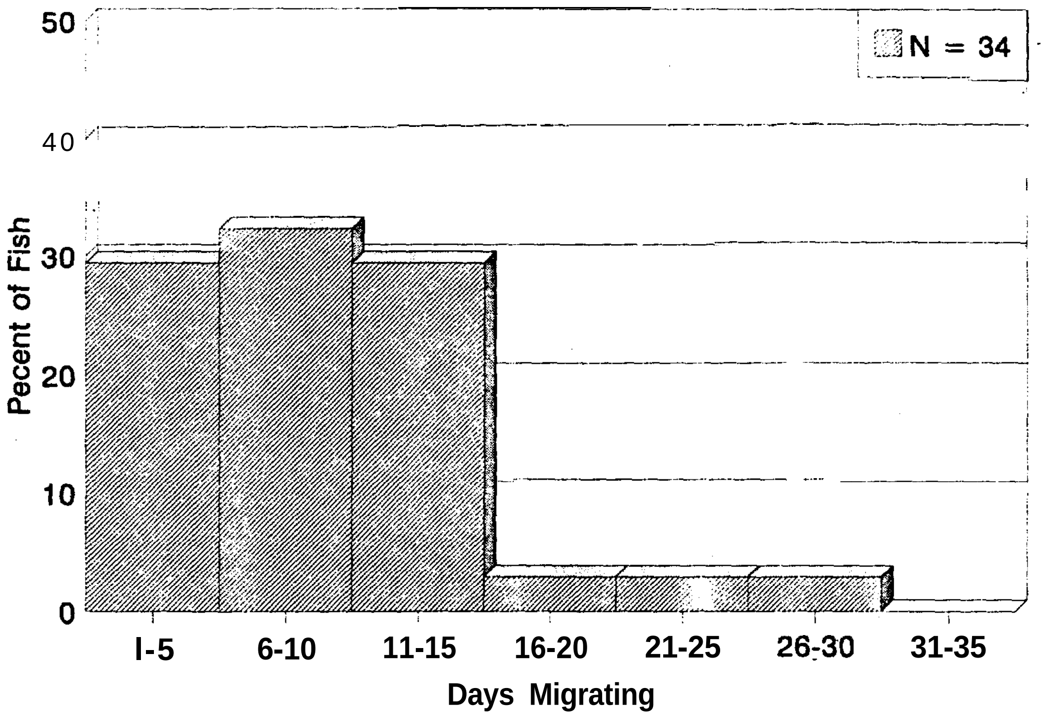


Figure 4. Duration of spawning migrations for radio-tagged rainbow trout.

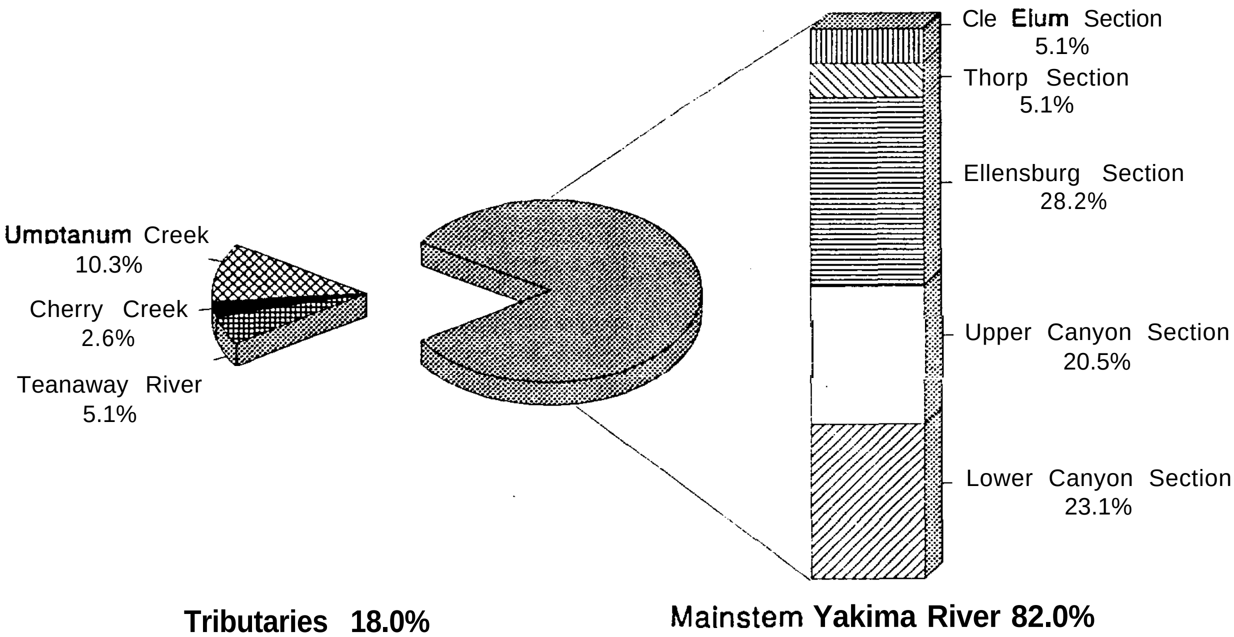


Figure 5. Spawning distribution of radio-tagged rainbow trout.

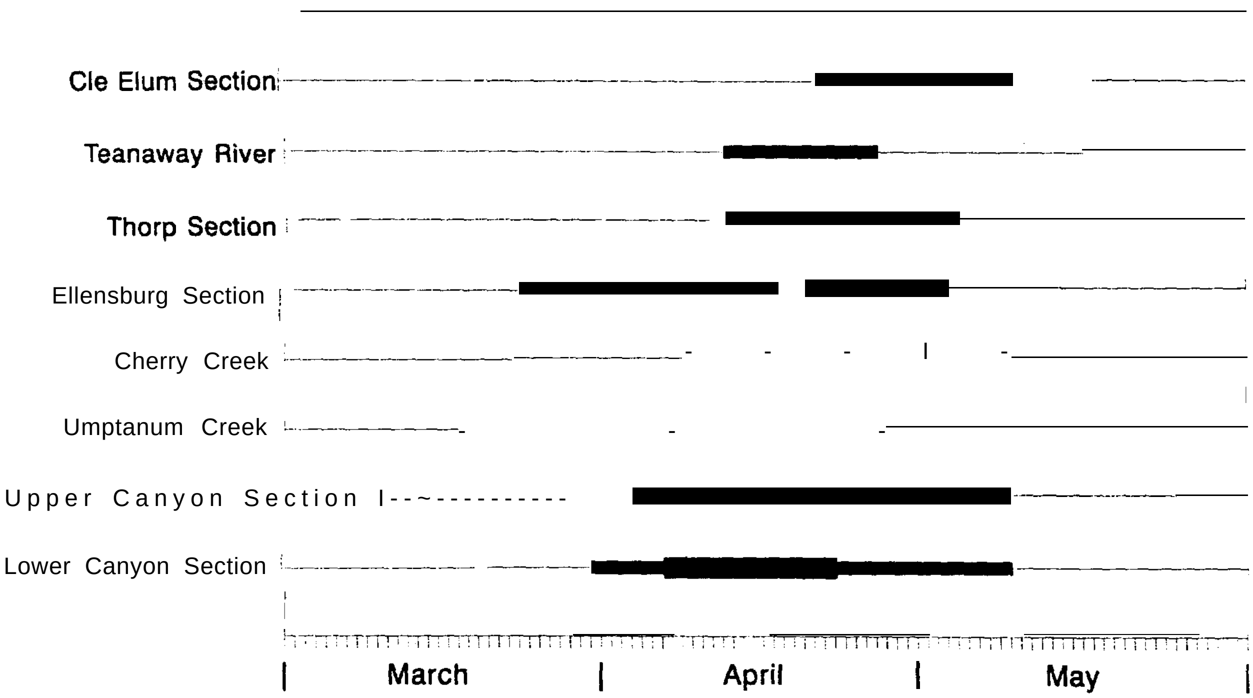


Figure 6. Range and peak time period of spawning by location of radio-tagged rainbow trout.

Radio-tagged rainbow trout were not observed spawning with steelhead during 1993. However, radio-tagged rainbow trout and steelhead spawned at similar times and locations in the Teanaway River during 1993 (Hockersmith et al. 1994). Spawning by radio-tagged fish in'the Teanaway River occurred during two periods, from 15 to 24 April and from 5 to 21 May. During each of these periods, one radio-tagged steelhead and one, radio-tagged rainbow trout entered the drainage within 50 hours of each other. One of the steelhead spawned in the West Fork of the Teanaway River after the radio-tagged rainbow trout migrated back into the Yakima River. However,. the other radio-tagged steelhead and rainbow trout pair not only entered the Teanaway River within 50 hours of each other but returned to the Yaki.ma River within 1 hour of each other.

Postspawning Behavior

Prespawning home range, postspawning home range, and post-spawning behavior for individual radio-tagged rainbow trout are summarized in Appendix Table C. Thirty-seven percent (14 fish) of the radio-tagged rainbow trout returned to prespawning home ranges after spawning- (Fig. 7). New home ranges were established by 13 fish (34%), with 4 fish establishing new home ranges near spawning locations. Ten fish (29%) moved out of the study area, died, or disappeared within the study area after spawning. During the summer, rainbow trout utilized shoreline habitats adjacent to the main current, with overhanging vegetation or undercut banks for cover. Summer home ranges were between 0.0 and 0.9 km in linear distance (mean = 0.35 km).

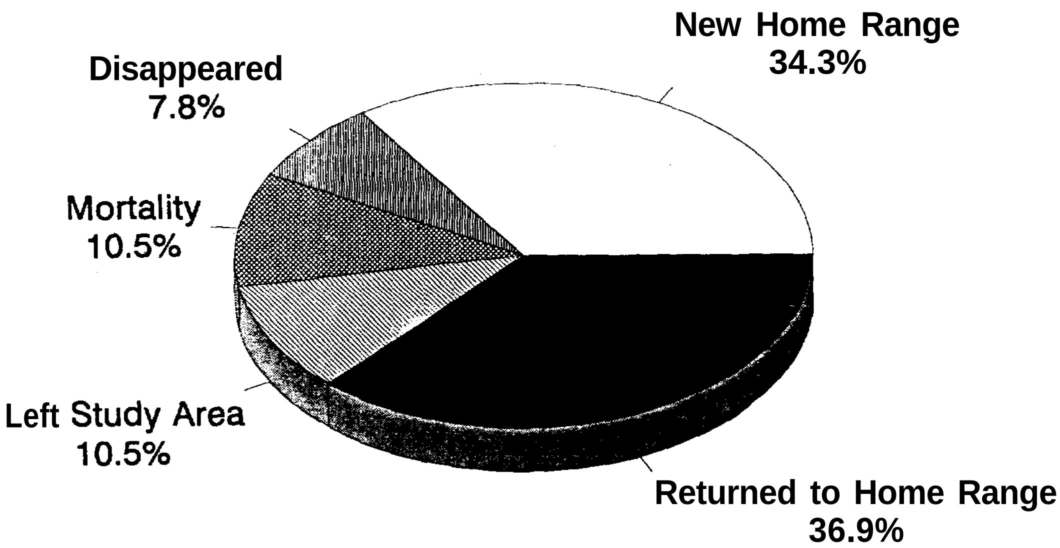


Figure 7. Postspawning disposition of radio-tagged rainbow trout.

Mortality

Observed mortality for radio-tagged rainbow trout was 13% (6 fish) (Table 3). Although no acute tagging mortality was observed, one tagging mortality occurred 35 days after release. Postspawning mortality was 6% (3 fish). Mortality due to predation was 4% (2 fish).

Seven radio-tagged rainbow trout moved out of the study area downstream past Roza Dam (three prior to spawning and four after spawning). Three of these fish remained stationary in the tailrace of Roza Dam and possibly died. The remaining five fish were not subsequently located by aerial surveys of the entire Yakima River Basin.

Four radio-tagged rainbow trout (6%) disappeared within the study area, possibly due to tag malfunction or illegal harvest.

DISCUSSION

Of the 52 wild rainbow trout radio-tagged in the upper Yakima River Basin to'determine spawning distribution, timing, and behavior, 75% spawned in 1993. They spawned between RKm 212.1 and RKm 298.8 in the mainstem Yakima River and in three tributaries to the mainstem (Cherry Creek, Umptanum Creek, and Teanaway River); however, rainbow trout have also been reported to spawn in the following Yakima River tributaries: Badger Creek, Wilson Creek, Dry Creek, Manashtash Creek, Taneum Creek, Swauk Creek, and Big Creek (Hindman et al. 1991, McMichael et al. 1992, Pearsons et al. 1993).

Table 3. Disposition and observed mortality of radio-tagged rainbow trout.

Disposition	Number of fish
Number tagged	52
Acute tagging mortality (< 2 days)	0
Delayed tagging mortality (> 2 days)	1
Predation mortality	2
Postspawning mortality	3
Prespawning movement out of the study area	3
Postspawning movement out of the study area	4
Disappearance within the study area	4

The majority of spawning migrations were less than 15 km in distance and were similar to the average 12.6 km migration in the Salmon River Basin, ID, reported for rainbow'trout by Bjornn and Mallet (1964).

Rainbow trout spawned between 24 March and 11 May in 1993, when water temperatures ranged from 7.2°C to 10.6°C. Spawning occurred earlier in lower elevations than in higher elevations, a distribution similar to that found by McMichael et al. (1992) and Hindman et al. (1991).

Overall mortality was 13%, with the majority of losses occurring after spawning or due to predation. However, this mortality rate may not be representative of the population, since the largest and, therefore, oldest segment of the population was tagged.

Fifteen percent (eight fish) of the radio-tagged rainbow trout migrated downstream out of the study area past Roza Dam. Of these, five fish were not located subsequently and may have left the Yakima River. Chapman and May (1986) described downstream movements of adult rainbow trout past Kootenai Falls (allegedly impassable to upstream migrants) in Montana as colonizing behavior of a rapidly expanding population. The upper Yakima River Basin historically supported abundant runs of adult steelhead; however, current populations are nearly extinct (Campton and Johnston 1985). The decline in abundance of steelhead in the upper Yakima River may have increased rainbow trout population densities, and fish migrating downstream may thus represent colonizers to other habitats.

Although steelhead and rainbow trout have different life-history forms, they are both of the same species; therefore, spawning interactions may occur in sympatric populations with overlapping spawning distributions and timing. Pearsons et al. (1993) speculated that the small population of steelhead, combined with the large population of rainbow trout in the upper Yakima River, increases the probability for spawning interactions. On the contrary, sympatric populations of anadromous steelhead and resident rainbow trout in the Deschutes River, Oregon, occur with little or no spawning interactions due to spatial and temporal spawning separation (Schroeder and Smith 1989). During 1993, the spawning distribution and timing of rainbow trout and steelhead overlapped in the upper mainstem Yakima River and Teanaway River drainage. Additionally, Pearsons et al. (1993) described similar overlapping of spawning in Umptanum Creek during 1990 and 1992, and Big Creek in 1992. 'Thus supplemented steelhead in the upper Yakima River Basin may spawn, to some degree, with rainbow trout, since their spatial and temporal spawning distributions overlap. A 13-year reintroduction of steelhead fry in Big Springs Creek, a tributary to the Lemhi River, ID, resulted in a reduction in abundance of adult rainbow trout (Bjornn 1978). If steelhead populations increase in the upper Yakima River Basin, rainbow trout population densities may decrease, due to competition and spawning interactions.

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REFERENCES

Bjornn, T. C. 1978 Survival, production and yield of trout and chinook salmon in the Lemhi River, Idaho. Bulletin 27. University of Idaho, College of Forestry, Wildlife and Range Sciences, Moscow, ID. (Available from U.S. Fish and Wildlife Service, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, ID 83843.)

Bjornn, T. C., and J. Mallet. 1964. Movements of planted and wild trout in an Idaho River System. Trans. Am. Fish. Soc. 93:70-76.

Campton, D. E., and J. M. Johnston. 1985. Electrophoretic evidence for a genetic admixture of native and nonnative rainbow trout in the Yakima River, Washington. Trans. Am. Fish. Soc. 114:782-793.

Chapman, D. W., and B. May. 1986. Downstream movement of rainbow trout past Kooteni Falls, Montanna. N. Am. J. Fish. Manage. 6:47-51.

Fast, D., J. Hubble, M. Kohn, and B. Watson. 1991. Yakima River spring chinook enhancement study. Report to Bonneville Power Administration, Contract DE-A179-83BP39461, 345 p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208-3621.)

Hart, L. G., and R. C. Summerfelt. 1975. Surgical procedures for implanting ultrasonic transmitters into flathead catfish (*Pylodictus olivaris*). Trans. Am. Fish. Soc. 104:56-59.

Hockersmith E., J. Vella, L. Stuehrenberg, R. N. Iwamoto, and G. Swan. 1995. Yakima River radio-telemetry study: Steelhead, 1989-93. Report to Bonneville Power Administration, Contract DE-A179-89BP00276, 98 p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208-3621.)

Hindman, J. N., G. A. McMichael, J. P. Olson, and S. A. Leider. 1991. Yakima River species interactions studies. Report to Bonneville Power Administration, Contract DE-BI79-89BPO1483, 75 p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208-3621.)

Johnson, O. 1964. River mile index Yakima River and tributaries. Report to the Columbia Basin Inter-agency Committee, Portland, OR, 40 p. (Available from Columbia Basin Inter-agency Committee, Room 325, Post Office Building, Broadway and Glisan, Portland, OR 97209.)

McMichael, G., J. Olson, E. Bartrand, M. Fisher, J. Hindman, and S. Leider. 1992. Yakima River species interactions studies. Report to Bonneville Power Administration, Contract DE-BI79-89BPO1483, 177 p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208-3621.)

Mellas, E. J., and J. M. Haynes. 1985. Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*) : effects of attaching telemetry transmitters. Can. J. Fish. Aquat. Sci. 42:488-493.

Pearsons, T., G. McMichael, E. Bartrand, M. Fischer, J. Monahan, and S. Leider. 1993. Yakima River species interactions studies. Report to Bonneville Power Administration, Contract DE-BI79-89BPO1483, 98 p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208-3621-j

Reinert, H. K., and D. Cundall. 1982. An improved surgical implantation method for radio-tracking snakes. Copeia 3:702-705.

Ross, M. J. 1982. Shielded-needle technique for surgically implanting radio-frequency transmitters in fish. Prog. Fish-Cult. 44(1):41-43.

Schroeder, R. K., and L. H. Smith. 1989. Life history of rainbow trout and effects of angling regulations, Deschutes River, Oregon. Information Report Number 89-6, 112 p. (Available from Oregon Department of Fish and Wildlife, 506 SW Mill Street, P.O. Box 59, Portland, OR 97207.)

Winter, J. D., V. B. Kuechle, D. B. Smith, and J. R. Tester. 1978. Equipment and methods for radio-tracking freshwater fish. Univ. Minn. Inst. Agric., Misc. Rep. 152. 45 p.

APPENDIX TABLES

Appendix Table A. Tagging data for radio-tagged rainbow trout.

Serial Number	Tagging Date	Surgical Time (min)	Number of Sutures	Length (mm)	Weight (gm)	Sex	Release Location (RKm)
D001	5 March	11.8	4	373	565		230
D002	5 March	8.5	3	348	437		230
D003	8 March	9.3	3	359	594	M	211
D004	5 March	12.5	4	348	448	M	230
D005	8 March	11.0	3	349	454		211
D006	5 March	10.3	3	355	546	F	230
D007	8 March	9.5	3	365	533		212
D008	8 March	15.0	4	336	447	F	212
D009	5 March	7.5	3	389	560	F	228
D010	8 March	10.5	3	366	570		211
D011	5 March	10.0	4	348	439	F	230
D012	8 March	9.0	3	354	524	F	211
D013	5 March	16.5	5	364	527		230
D014	8 March	13.0	3	320	371	M	210
D015	8 March	8.5	4	338	483	F	211
D016	5 March	17.0	3	373	571	F	228
D017	8 March	7.1	3	360	550	F	212
D018	5 March	9.3	3	348	473	M	228
D019	8 March	11.8	3	362	566	M	211
D020	5 March	10.7	4	353	543	F	230
D021	8 March	10.0	3	337	428	M	211
D022	5 March	7.0	3	3 5.4	509	F	228
D023	8 March	7.8	4	370	522	M	211
D024	5 March	6.8	3	360	546	F	228
D025	8 March	11.0	3	319	313		212
D026	5 March	11.0	3	372	588		228
D027	a March	10.5	3	355	482		212
D028	5 March	8.2	3	340	454		228
D029	8 March	10.0	4	389	546	M	210
D030	5 March	11.1	3	352	457		228
D031	8 March	13.8	3	335	430	F	211
D032	5 March	10.0	3	350	515		230
D033	8 March	11.7	3	361	586	F	210
D034	5 March	9.8	3	339	433		230
D035	8 March	7.9	3	357	461		212
D036	5 March	9.3	4	375	567	F	230

Appendix Table A. Continued.

Serial Number	Tagging Date	Surgical Time (min)	Number of Sutures	Length (mm)	Weight (gm)	Sex	Release Location (RKm)
D037	8 March	15.0	4	326	418	M	211
D038	5 March	7.3	4	357	530	F	228
D039	8 March	8.5	3	390	740	F	210
D040	5 March	13.0	3	355	509	M	230
D041	8 March	12.5	4	398	700	F	211
D042	5 March	9.8	3	337	501	M	228
D043	8 March	8.5	3	375	600	M	211
D044	5 March	8.8	4	356	519		228
D045	8 March	9.0	3	337	574		2 1 1
D046	5 March	8.3	3	343	428		230
D047	8 March	10.0	3	335	317		211
D048	5 March	10.0	3	349	486	F	230
D049	8 March	13.0	5	390	637	F	211
D050	5 March	8.0	3	332	455	M	230
D@40	7 April		4	375	492	M	228
D@43	13 April	9.0	4	520	1434	F	212

Appendix Table B. Spawning migration timing and distance, and spawn timing and location of radio-tagged rainbow trout.

Serial number	Spawning migration		Spawning	Spawning location	
	dates	distance (km)	dates	river	RKm
D001	23-26 Mar	>7.9	>26 Mar	Yakima	238.9-258.4
D002	3-6 May	1.0	6-10 May	Yakima	230.7
D003	8-12 Apr	11.7	12-16 Apr	Yakima	223.3
D004	16-20 Apr	0.0	20 Apr-4 May	Yakima	238.5
D005	13-22 Apr	1.3	22 Apr-6 May	Yakima	212.2
D006	13-21 Apr	11.9	21 Apr-4 May	Yakima	242.0
D007	31 Mar-8 Apr	3.1	a-13 Apr	Yakima	214.8
D008	13-19 Apr	12.4	19-22 Apr	Yakima	224.6
D010	3-6 May	0.6	6 May	Yakima	212.1
D011	8 Mar-5 Apr	7.7	5-6 Apr	Yakima	235.7
D012	1-16 Apr	20.6	15-22 Apr	Yakima	231.9
D014	25 Mar-Apr 12	2.6	12-19 Apr	Yakima	219.8
D016	31 Mar-l Apr	1.1	1-5 Apr	Yakima	229.0
D017	16 Apr-4 May	53.4	4-S May	Yakima	265.5
D018	19-31 Mar	2.1	31 Mar-13 Apr	Umptanum	0.0
D020	13-16 Apr	>6.9	16 Apr-6 May	Cherry	>1.0
D021	6-15 Apr	>27.5	15-20 Apr	Yakima	238.9-250.4
D022	8-22 Apr	>10.0	22-26 Apr	Yakima	238.9-258.4
D023	19-31 Mar	17.2	31 Mar-8 Apr	Yakima	224.8
D024	8-13 Apr	1.0	13-26 Apr	Yakima	228.5
D026	1-6 Apr	8.7	6-8 Apr	Yakima	238.1
D027	29 Apr-3 May	0.3	>3 May	Yakima	212.5
D028	8-20 Apr	0.8	19-22 Apr	Umptanum	0.2
D029	10 Mar-12 Apr	87.2	12 Apr	Yakima	298.8
D030	23-26 Mar	5.6	26-31 Mar	Umptanum	1.6
D032	22-28 Apr	13.4	28 Apr-4 May	Yakima	242.8
D034	16-29 Apr	1.8	29 Apr-6 May	Yakima	231.5
D036	8-19 Apr	Y-20.8	19 Apr-3 May	Yakima	251.0-258.4
D037	13-16 Apr	>46.3	>21 Aps	Yakima	>258.4
D038	8-12 Apr	4.0	12-13 Apr	Yakima	232.0
D039	25 Mar-21 Apr	83.7	21-27 Apr	Yakima	294.4
D041	6-21 Apr	>75.1	21-23 Apr	Teanaway	>3.2
D044	20-22 Apr	7.4	22-28 Apr	Yakima	236.7
D045	22 Apr-6 May	6.6	6-10 May	Yakima	217.4
D045	20-21 April	>8.8	21-25 Apr	Yakima	238.9-258.4
D048	6-8 Apr	5.6	8-12 Apr	Yakima	235.4
D049	19-24 Mar	26.5	24 Mar-l Apr	Yakima	238.0
D050	16-25 Mar	2.4	25-31 Mar	Umptanum	0.6
D@43	28 Apr-S May	>75.6	5-11 May	Teanaway	>3.2

Appendix Table C. Prespawning home range, postspawning home range and postspawning behavior of radio-tagged rainbow trout.

Serial number	Prespawning home range (Rkm)	Postspawning home range (Rkm)	Postspawning behavior
D001	229.9		Postspawning disappearance
DO02	229.8	230.7	New home range near spawning location
D003	211.6		Postspawning mortality
D004	230.4	238.5	New home range near spawning location
D005	210.9	212.1	New home range near spawning location
D006	230.9		Postspawning mortality
D007	211.7	205.8	Below Roza Dam
D008	212.2	211.1	New home range near prespawning home range
D010	211.4	211.4	Returned to prespawning home range
D011	228.0	234.9	New home range near spawning location
D012	211.3	212.4	New home range near prespawning home range
D014	210.8-217.2	219.8	New home range near spawning location
D016	228.6	228.5	Returned to prespawning home range
D017	212.1	213.8	New home range near prespawning home range
D018	226.1	229.4	New home range
DO20	231.2		Postspawning disappearance
D021	211.6		Below Roza Dam
no22	228.2	228.2	Returned to prespawning home range
DO23	207.6	209.6	New home range near prespawning home range
DO24	227.0	227.0-227.4	New home range near prespawning home range
DO26	229.4		Below Roza Dam
DO27	212.1	212.4	New home range near spawning location
DO28	225.7	227.5-220.5	New home range near prespawning home range
DO29	211.6		Postspawning mortality
DO30	229.0	213.7	New home range
DO32	229.4	231.4	New home range near prespawning home range
DO34	229.8	231.4	New home range near spawning location
DO36	230.3	231.1	New home range near prespawning home range
DO37	212.1		Postspawning disappearance
DO38	228.0		Postspawning disappearance
DO39	210.8	210.3	Returned to home range
DO41	211.4	211.1	Returned to home range
DO44	229.3	229.3	Returned to home range
DO45	210.8	210.5	Returned to home range
DO46	230.3	229.8	Returned to home range
DO48	229.8	230.2	Returned to home range
DO49	211.4	210.3-211.3	Returned to home range
DO50	226.6	228.6	Postspawning mortality
D@43	210.8		Below Roza Dam